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TITLE: HARMONIC DRIVE ELECTROSTATIC MOTOR

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APPL-NO: JP02220392
APPL-DATE: August 21, 1990

INT-CL_(IPC): H02N001/00

ABSTRACT:
PURPOSE: To increase output torque and to prevent slip of rotor by arranging magnets and drive electrodes, while laminating or partitioning, on the surface of a nonmagnetic stator casing and forming a rotor electrode of a conductive ferromagnetic body.

CONSTITUTION: A stator casing 2 is formed of a nonmagnetic material into a tube. A plurality of tubular magnets 7a-7d are then arranged, with gaps in the axial direction, on the inner circumferential face of the stator casing 2. Furthermore, an insulation layer 3 composed of an insulating adhesive is formed entirely on the inner circumferential faces of the magnets 7a-7d and a plurality of drive electrodes P1-P8 are arranged, with predetermined pitches in the circumferential direction, on the surface of the insulation layer 3 thus

forming a rotor rolling face 5 on the inner circumferential faces of the drive electrodes P1-P8. A metallic hollow tubular rotor 11 having outer diameter shorter than the inner diameter of the stator 1 is then inserted into the stator 1. The rotor 11 is constituted of a rotor electrode 12 composed of a conductive ferromagnetic material and an insulating film 13.

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㊿発明の名称　ハーモニツクドライブ型静電モータ

㉑特　願　平2-220392
㉒出　願　平2(1990)8月21日

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明　細　書

1．発明の名称

ハーモニックドライブ型静電モータ

2．特許請求の範囲

(1)　ステータケーシングの表面に複数片の駆動電極を備えたステータと、ステータのロータ転がり面に沿って転動するロータ電極と、ロータ電極と駆動電極を電気的に絶縁させる絶縁膜とからなるハーモニックドライブ型静電モータにおいて、

非磁性材からなるステータケーシングの表面に、磁石と前記駆動電極とを積層状態で、もしくは区分的に設け、前記ロータ電極を導電性の強磁性体によって形成したことを特徴とするハーモニックドライブ型静電モータ。

3．発明の詳細な説明

［産業上の利用分野］

本発明は、静電モータの一種であるハーモニックドライブ型静電モータに関する。

［背景技術］

ハーモニックドライブ型静電モータは、ステータに形成された複数の駆動電極とロータとの間に駆動電圧を印加して得られる静電容量の時間的変化を駆動のエネルギー源とするものであり、二次元的構成であるため、小型化が可能である。

このため実用化をめざしてハーモニックドライブ型静電モータの研究が進められている。

第6図(a)(b)に示すものは、現在提案されているハーモニックドライブ型静電モータの構造であって、ステータ51とロータ61から構成されている。ステータ51は、円筒状をした金属製ステータケーシング52の内周面を絶縁接着剤からなる絶縁層53で覆い、絶縁層53の上に湾曲した複数片の駆動電極T1，T2，…をエアーギャップ54をあけて配置し、絶縁層53によって各駆動電極T1，T2，…をステータケーシング52の内周面に接着固定させたものであり、駆動電極T1，T2，…の内周面にロータ転がり面55を形成している。

しかして、駆動電極T1，T2，…とロータ電極62との間に印加された電圧によって働く静電

吸引力により絶縁膜63を介してロータ61の外周面とステータ51の駆動電極T1，T2，…とが接しており、駆動電極T1，T2，…の電圧印加位置を順次切り換えると、ロータ61がステータ51内で歳差運動を行なう。

［発明が解決しようとする課題］

上記のようなハーモニックドライブ型静電モータにあっては、その出力トルクは、駆動電極とロータ電極の間に働く静電吸引力によって発生し、ロータとステータとの間に働く摩擦力によって制限を受ける。すなわち、ロータとステータの間にスリップが発生すると、大きな出力トルクを得ることができない。

しかしながら、上記のように、駆動電極とロータ電極との間の静電吸引力のみによるロータ及びステータ間の摩擦力は小さく、大きな負荷が加わると、ロータがスリップし、大きな出力トルクを発生させることができなかった。

特に、ロータに同期外れが生じた時に、ロータとステータの間の摩擦力が小さくなり、ロータがスリップし易かった。

本発明は叙上の技術的背景に鑑みてなされたものであり、その目的とするところは、ロータとステータの間の摩擦力を増加させると共に同期外れ時でもホールディングトルクを発生させることができるハーモニックドライブ型静電モータを提供することにある。

［課題を解決するための手段］

本発明のハーモニックドライブ型静電モータは、ステータケーシングの表面に複数片の駆動電極を備えたステータと、ステータのロータ転がり面に沿って転動するロータ電極と、ロータ電極と駆動電極を電気的に絶縁させる絶縁膜とからなるハーモニックドライブ型静電モータにおいて、非磁性材からなるステータケーシングの表面に、磁石と前記駆動電極とを積層状態で、もしくは区分的に設け、前記ロータ電極を導電性の強磁性体によって形成したことを特徴としている。

［作用］

本発明にあっては、ロータ電極及び駆動電極間に働く静電吸引力とロータ電極及び磁石間に働く磁力により、ロータがステータに吸引されているので、ロータとステータとの間の摩擦力が大きくなり、ロータに大きな負荷が加わってもロータがスリップしにくくなり、出力トルクが増大する。

また、ロータ電極と磁石との間に働く磁力のため、ロータ電極と駆動電極の間に電圧を印加していなくてもホールディングトルクが生じている。従って、ロータに同期外れが生じても、ロータがロータ転がり面から浮くことがなく、ロータのスリップを防止することができる。

［実施例］

以下、本発明の実施例を添付図に基づいて詳述する。

第1図(a)(b)は、本発明の一実施例のハーモニックドライブ型静電モータAの概略構成を示しており、ステータ1とロータ11とから構成されている。

2は、ステータケーシングであって、非磁性の金属材料によって円筒状に形成されている。ステータケーシング2の内周面には、第1図(b)に示すように、円筒状をした複数個の磁石7a～7dが互いに間隙をあけて軸心方向に配列され、各磁石7a～7d間には絶縁層6が充填されており、これらの磁石7a～7dは、外周面の接着剤層8と絶縁層6によってステータケーシング2の内周面に固定されている。各磁石7a～7dは、それぞれ軸心方向に分極しており、極性が交互になるように配列され、隣り合う磁石7a～7d同志は絶縁層6を隔てて互いにN極とS極を対向させられている。さらに、これらの磁石7a～7dの内周全面に絶縁接着剤からなる絶縁層3を形成し、絶縁層3の表面に複数極（図示例では、8極）の駆動電極P1～P8を周方向に一定ピッチごとに配置し、絶縁層3によって駆動電極P1～P8を各磁石7a～7dの内周面に接着固定すると共に絶縁層3によって駆動電極P1～P8と磁石7a～7dとの間を絶縁している。また、各駆動電極P1～P8間は、エアギャップ4によって互いに絶縁されており、各駆動電極P1～P8の内周面

にロータ転がり面5が形成されている。

上記ステータ1内には、外径がステータ1の内径よりも小さな金属製の中空円筒状もしくは中実円柱状をしたロータ11が挿入されており、ロータ11は、ステータ1とほぼ同じ長さを有している。ロータ11は、導電性を有する強磁性材からなるロータ電極12と絶縁膜13とからなっており、駆動電極P1～P8とロータ電極12とが電気的に導通しないよう、ロータ電極12の外周面もしくは全表面は、絶縁性もしくは誘電性の絶縁膜13によって被覆されている。もちろん、絶縁膜13をロータ11に設けず、ステータ1の内周面に設けても差し支えない。ロータ電極12は、支持部（図示せず）を介して常時接地されている。

一方、ハーモニックドライブ型静電モータAの駆動制御部21は、第2図に示すように、直流電源23、発振器22及びスイッチング回路24からなっている。各駆動電極P1～P8には、駆動電極用ケーブル25を介してスイッチング回路24が接続されており、スイッチング回路24は、発振器22からの信号に同調して直流電源23によって与えられる駆動電圧Vを印加する駆動電極P1～P8を順次切り換えている。

第3図に示すものは、スイッチング回路24によって制御されている各駆動電極P1～P8の電圧の変化を示すタイムチャートである。このように、各駆動電極P1～P8は、スイッチング回路24により駆動電圧Vの印加位置を周方向へ1つずつ移動させられるので、静電吸引力によりロータ11の吸引される方向が順次反時計回りに移動し、これによってロータ11がステータ1の内周面を転動して反時計回りに公転し、同時に時計回り（第2図の矢印方向）に自転する。なお、この駆動方法は一例であって、例えば複数の駆動電極に同時に電圧を印加しながら、電圧印加位置をスイッチングさせてもよい。

このようにロータ11がステータ1の内周面に沿って転動する時、ロータ11は、ロータ電極12と駆動電極P1～P8との間に働く静電吸引力によってステータ1に吸引されるが、加えて、各磁石7a～7dの磁力線が強磁性体のロータ電極12を磁路として閉ループを作るので、ロータ11は、この磁力線によって長さ方向にわたって各部をほぼ均等に吸引される。従って、磁石7a～7dの磁気的吸引力（磁力）が加わることにより、ロータ11がより大きな力でステータ1に吸引され、ロータ11とステータ1との間の摩擦力が増大する。この結果、大きな負荷が加わってもロータ11がスリップしにくくなり、より大きな出力トルクを得ることができる。また、ロータ11が、同期外れによって駆動電圧Vを印加されている駆動電極からずれても、磁石7a～7dの磁気的吸引力によってホールディングトルクを確保することができ、ロータ11がスリップしにくくなる。

第4図(a)(b)に示すものは本発明のさらに別な実施例である。このハーモニックドライブ型静電モータBでは、非磁性材からなるステータケーシング2の内周面の両端部にそれぞれ円筒状をした磁石7e，7fを配置し、この磁石7e，7f間に複数片の駆動電極P1～P8を配置している。この磁石7e，7fは、内周面側と外周面側に分極されており、両磁石7e，7fで極性が互いに反対向きとなっている。また、駆動電極P1～P8とステータケーシング2の間、及び駆動電極P1～P8と磁石7e，7fの間は、絶縁層3，9によって絶縁及び固定されている。しかして、一方の磁石7eのN極から出た磁力線は、同じ磁石7eのS極に戻り、他方の磁石7fのN極から出た磁力線もその磁石7fのS極に戻り、それぞれ閉ループを構成する。これにより、ロータ11は、駆動電極P1～P8との間の静電吸引力に加えて、磁石7e，7fとの間の磁力によっても吸引され、ロータ11とステータ1との圧接力が増大して摩擦力が大きくなる。

また、この実施例では、両磁石7e，7fの内径は、駆動電極P1～P8の内径よりもわずかに小さくなっており、磁石7e，7fの内周面がロータ転がり面5となっている。このためロータ11は、駆動電極P1～P8に接触することなく、磁石7e，7fの内周面を転動する。磁石7e，

7fは駆動電極P1～P8のようにエアギャップ4を有していないので、ロータ11は、エアギャップ4に落込んだりすることなく、滑らかに回転し、回転音も減少する。

第5図(a)(b)(c)に示すものは本発明のさらに別な実施例である。このハーモニックドライブ型静電モータCでは、ステータケーシング2の内周面において、駆動電極P1～P8の両側に配置された磁石7g，7hの構造が第4図(a)(b)の実施例と異なっている。この実施例では、第5図(a)に示すように、円筒状の各磁石7g，7hを複数片に分割してあり、各磁石片10は内周面側と外周面側とで分極しており、隣り合う磁石片10同志の分極の向きが交互に逆向きとなっている。

なお、上記実施例においては、ステータケーシングの内周面に駆動電極を設け、ステータの中空内部空間にロータを挿入している（インナーロータ方式）が、本発明は、このようなタイプのハーモニックドライブ型静電モータに限らず、ステータケーシングの外周面に駆動電極を設け、ステータの外周に円筒状をしたロータを外挿させたもの（アウターロータ方式）にも実施することができる。

［発明の効果］

本発明によれば、ロータとステータ間に磁石による吸引力が加わるので、ロータとステータとの間の摩擦力が大きくなり、ロータに大きな負荷が加わってもロータがスリップしにくくなり、出力トルクが増大する。

また、ロータ電極と駆動電極の間に電圧を印加していなくても磁石によってホールディングトルクが生じている。従って、ロータに同期外れが生じても、ロータがロータ転がり面から浮くことがなく、ロータのスリップを防止することができる。

4．図面の簡単な説明

第1図(a)(b)は本発明の一実施例を示す正面図及び断面図、第2図は同上のモータの駆動方法を示す概略構成図、第3図は同上の各駆動電極の印加電圧の変化を示すタイムチャート、第4図(a)(b)は本発明の別な実施例を示す正面図及び断面図、第5図(a)(b)は本発明のさらに別な実施例を示す正面図及び断面図、第5図(c)は第5図(b)のZ－Z断面図、第6図(a)(b)は背景技術の欄で説明したハーモニックドライブ型静電モータの正面図及び断面図である。

1…ステータ
2…ステータケーシング
P1～P8…駆動電極
5…ロータ転がり面
7a～7h…磁石
11…ロータ
12…ロータ電極
13…絶縁膜

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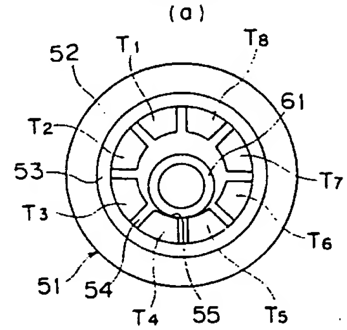
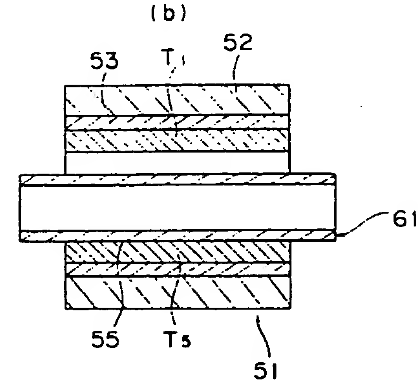
第6図

(a)

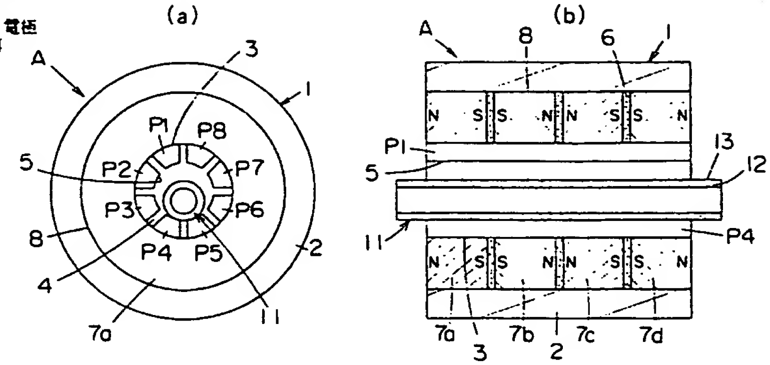


(b)

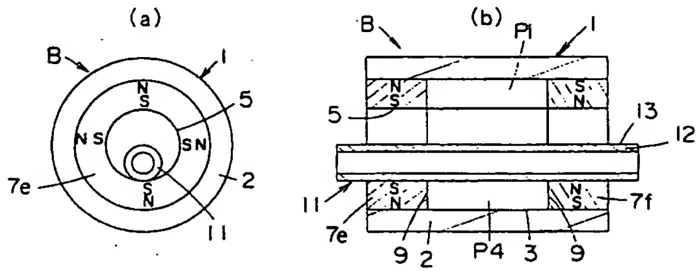


1…ステータ
2…ステータケーシング
P1～P8…駆動電極
5…ロータ転がり面
7a～7f…磁石
11…ロータ
12…ロータ電極
13…絶縁膜

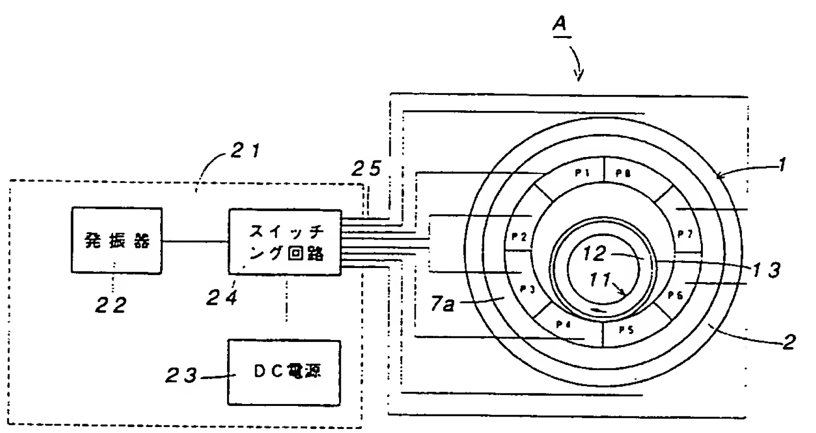
第 1 図



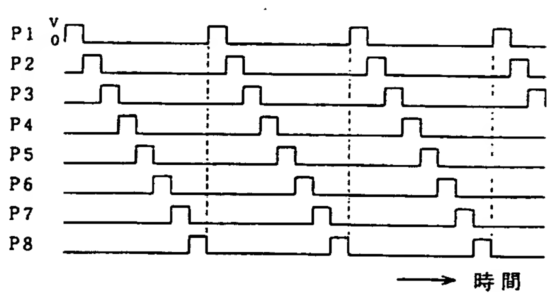
第 4 図



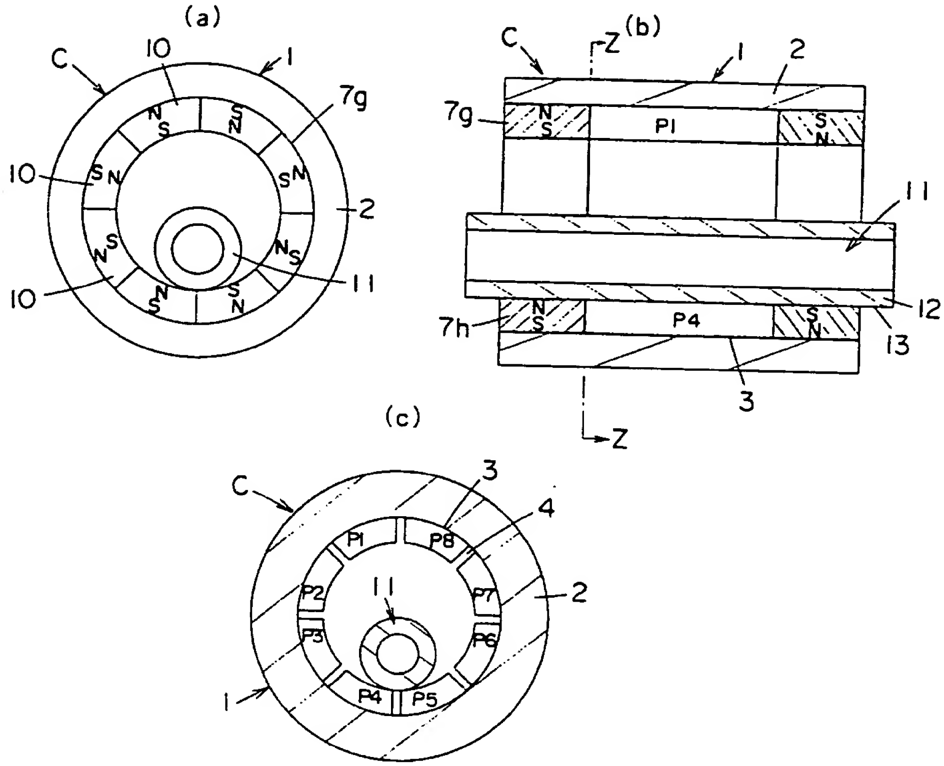
第 2 図



第 3 図



第 5 図



PTO 02-2483

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4-101672

HARMONIC DRIVE-TYPE ELECTROSTATIC MOTOR
[Hamonikku Doraibu Gata Seiden Mota]

Katsumi Hosoya, Masatoshi Oba, and Minoru Sakata

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Specification

/1 [1]

1. Title of the Invention: HARMONIC DRIVE-TYPE ELECTROSTATIC MOTOR

2. Claim

A harmonic drive-type electrostatic motor with the following characteristics: In a harmonic drive-type electrostatic motor which consists of a stator which is endowed with multiple drive electrodes on the surface of a stator casing, a rotor electrode which becomes tumbled along the rotor tumble plane of the stator, and an insulating film which electrically insulates said rotor electrode and drive electrodes,

A magnet and the aforementioned drive electrodes are configured on the surface of a stator casing which consists of a non-magnetic material in a laminated state or in a compartmentalized fashion, and the aforementioned rotor electrode is formed by an electroconductive ferromagnet.

3. Detailed explanation of the invention

(Industrial application fields)

The present invention concerns a harmonic drive-type electrostatic motor, which represents a type of electrostatic motors.

[1]Numbers in the margin indicate pagination in the foreign text

(Background technology)

A harmonic drive-type electrostatic motor uses as a drive energy source the temporal variation of an electrostatic capacitance which is obtained by impressing a drive voltage between multiple drive electrodes formed on a stator and a rotor, and by virtue of its two-dimensional constitution, it contributes to size reduction. Studies are being conducted on such an electrostatic motor in the context of providing a practical system.

The structure of a harmonic drive-type electrostatic motor proposed in the prior art is shown in Figures 6 (a) and (b), and it is constituted by the stator (51) and the rotor (61). The stator (51) is obtained by blanketing the inner circumferential plane of the metallic stator casing (52), which is characterized by a cylindrical shape, with the insulating layer (53), which consists of an insulating adhesive, by configuring multiple curvy drive electrodes T1, T2, ... on the insulating layer (53) while the air gap (54) is being secured between them, and by adhering and fixing the respective drive electrodes T1, T2, ... to the inner circumferential plane of the stator casing (52) via the insulating layer (53), and the rotor tumble plane (55) is formed on each of the drive electrodes T1, T2, ...

The outer circumferential plane of the rotor (61) and the drive electrodes T1, T2, ... of the stator (51), furthermore, become mutually contiguated via the insulating film (63) under the pervasion of an /2

electrostatic capacitance suction force which becomes generated by

the voltage impressed between the drive electrodes T1, T2, ... and the rotor electrode (62), and in a case where the voltage impression positions of the drive electrodes T1, T2, ... are sequentially switched, the rotor (61) comes to engage in a precession within the stator (51).

(Problems to be solved by the invention)

The output torque of the aforementioned harmonic drive-type electrostatic motor becomes generated by an electrostatic suction force which becomes exerted between the drive electrodes and the rotor electrode, and accordingly, a limitation comes to be imposed by a frictional force which becomes exerted between the rotor and stator. In other words, in a case where a slip occurs between the rotor and stator, it becomes impossible to achieve a high output torque.

As has been mentioned above, however, the frictional force between the rotor and stator attributed exclusively to the electrostatic suction force between the drive electrodes and rotor electrode is minimal, and accordingly, the rotor comes to slip in response to the impression of a high load, as a result of which it becomes impossible to generate a high output torque.

In a case where the desynchronization of the rotor has occurred, in particular, the frictional force between the rotor and stator becomes minimized, as a result of which the slip of the rotor becomes likely.

The objective of the present invention, which has been conceived against the foregoing technical backdrop, is to provide a harmonic drive-type electrostatic motor which is capable of elevating the frictional force between a rotor and a stator and of generating a holding torque even at a time of desynchronization.

(Mechanism for solving the problems)

The following constitution is provided by the harmonic drive-type electrostatic motor of the present invention: In a harmonic drive-type electrostatic motor which consists of a stator which is endowed with multiple drive electrodes on the surface of a stator casing, a rotor electrode which becomes tumbled along the rotor tumble plane of the stator, and an insulating film which electrically insulates said rotor electrode and drive electrodes, a magnet and the aforementioned drive electrodes are configured on the surface of a stator casing which consists of a non-magnetic material in a laminated state or in a compartmentalized fashion, and the aforementioned rotor electrode is formed by an electroconductive ferromagnet.

(Functions)

As far as the present invention is concerned, the rotor is suctioned toward the stator by an electrostatic suction force which becomes exerted between the rotor electrode and drive electrodes and a magnetic force which becomes exerted between the rotor electrode and magnet, as a result of which the frictional force

between the rotor and stator becomes enhanced, and since the slip of the rotor becomes unlikely even in a case where a high load is impressed on the rotor, the output torque can be elevated.

Even in a case where no voltage is impressed between the rotor electrode and magnet, furthermore, a holding torque arises under the pervasion of the magnetic force exerted between the rotor electrode and magnet. Even if the rotor becomes desynchronized, therefore, the hover of the rotor from the rotor tumble plane can be avoided, and the slip of the rotor can be prevented.

(Application examples)

In the following, an application example of the present invention will be explained in detail with reference to attached figures.

Figures 1 (a) and (b) show an approximate constitution of the harmonic drive-type electrostatic motor A of an application example of the present invention, which is constituted by the stator (1) and the rotor (11).

(2) is a stator casing which has been obtained by molding a non-magnetic metallic material into a cylindrical shape. As Figure 1 (b) indicates, multiple cylindrical magnets (7a) ~ (7d) are configured on the inner circumferential plane of the stator casing (2) via gaps along the axial direction, whereas the insulating layer (6) is filled into the gap between adjacent members of the respective magnets (7a) ~ (7d), whereas these magnets (7a) ~ (7d) are fixed to the inner circumferential plane of the stator casing (2) by the adhesive layer (8) on the outer circumferential plane

and the insulating layer (6). The respective magnets (7a) ~ (7d) are each polarized along the axial direction while being configured in mutually alternating polarities, and the N pole and S pole of adjacent members of the respective magnets (7a) ~ (7d) oppose one another via the insulating layer (6). The insulating layer (3), which consists of an insulating adhesive, furthermore, is formed on the entire inner circumferential plane of each of these magnets (7a) ~ (7d), and multipolar (octapolar in the example shown in the figures) drive electrodes P1 ~ P8 are configured on the surface of the insulating layer (3) via a certain pitch along the circumferential direction, whereas the drive electrodes P1 ~ P8 are adhered and fixed to the inner circumferential plane of each of the magnets (7a) ~ (7d) via the insulating layer (3) while the drive electrodes P1 ~ P8 and magnets (7a) ~ (7d) are being mutually insulated via the insulating layer (3). Adjacent members of the respective drive electrodes P1 ~ P8, furthermore, are mutually insulated via the air gap (4), and the rotor tumble plane (5) is formed on the inner circumferential plane of each of the respective drive electrodes P1 ~ P8. /3

The rotor (11), which is made of a metal, which is characterized by a hollow cylindrical or non-hollow cylindrical shape, and the outer diameter of which is smaller than that of the aforementioned stator (1), is inserted into said stator (1), and the length of the rotor (11) is virtually identical to that of the stator (1). The rotor (11) consists of the rotor electrode (12), which consists of an electroconductive ferromagnetic material, and the insulating

film (13), and the outer circumferential plane of the rotor electrode (12) or its entire surface is blanketed with the insulating film (13), which is either insulating or dielectric, for precluding the electric conduction of the drive electrodes P1 ~ P8 and the rotor electrode (12). It goes without saying that the insulating film (13) can be configured on the inner circumferential plane of the stator (1) instead of being configured on the rotor (11). The rotor electrode (12) remains constantly grounded via a support unit (not shown in the figures).

The drive control unit (21) of the harmonic drive-type electrostatic motor A, on the other hand, is constituted by the DC power source (23), the oscillator (22), and the switching circuit (24), as Figure 2 indicates. The switching circuit (24) is connected to each of the respective drive electrodes P1 ~ P8 via the drive electrode cable (25), whereas said switching circuit (24) sequentially switches among the drive electrodes P1 ~ P8 for impressing the drive voltage V, which has been supplied from the DC power source (23), in synchrony with a signal obtained from the oscillator (22).

Figure 3 is a time chart which shows the voltage variations of the respective drive electrodes P1 ~ P8 as they are being controlled by the switching circuit (24). Thus, the impression position of the drive voltage V is shifted by one member each of the respective drive electrodes P1 ~ P8 along the circumferential direction by the switching circuit (24), as a result of which the suction position of the rotor (11) sequentially shifts counterclockwise under the

pervasion of the electrostatic suction force, based on which the rotor (11) becomes transitively rotated counterclockwise while being tumbled on the inner circumferential plane of the stator (1) and while simultaneously revolving intransitively along the clockwise direction (direction of the arrow in Figure 2). Incidentally, this drive method is merely an example, and it is also possible to switch the voltage impression positions while a voltage is being simultaneously impressed on multiple drive electrodes.

While the rotor (11) is thus tumbled along the inner circumferential plane of the stator (1), the rotor (11) becomes suctioned toward the stator (1) by an electrostatic suction force which becomes exerted between the rotor electrode (12) and the drive electrodes P1 ~ P8, and since the magnetic rays of the magnets (7a) ~ (7d) additionally form a closed loop while the rotor electrode (12), which consists of a ferromagnet, avails itself as a magnetic path, the respective portions of the rotor (11) become nearly evenly suctioned along the longitudinal direction by said magnetic rays. Upon the exertion of the magnetic suction force (magnetic force) of the magnets (7a) ~ (7d), therefore, the rotor (11) becomes suctioned toward the stator (1) more decisively, as a result of which the frictional force between the rotor (11) and stator (1) increases. Even in a case where a high load is impressed, therefore, the slip of the rotor (11) becomes unlikely, and a higher output torque can be obtained. Even in a case where the rotor (11) becomes desorbed from the drive electrodes on which

the drive voltage V is being impressed due to desynchronization, furthermore, the requisite holding torque can be secured based on the magnetic suction force of the magnets (7a) ~ (7d), and the slip of the rotor (11) becomes unlikely.

Another application example of the present invention is shown in Figures 4 (a) and (b). As far as this harmonic drive-type electrostatic motor B is concerned, the magnets (7e) and (7f), which are each characterized by a cylindrical shape, are configured at both ends of the inner circumferential plane of the stator casing (2), which consists of a non-magnetic material, whereas multiple drive electrodes P1 ~ P8 are configured between these magnets (7e) and (7f). These magnets (7e) and (7f) are polarized respectively toward the inner circumferential plane side and the outer circumferential plane side, and the respective polarities of the magnets (7e) and (7f) are mutually opposite. The gap between the drive electrodes P1 ~ P8 and the stator casing (2) and the gap between the drive electrodes P1 ~ P8 and the magnets (7e) and (7f) are insulated fixedly by the insulating layers (3) and (8), respectively. A magnetic ray emitted from the N pole of one magnet (7e) returns to the S pole of the same magnet (7e), whereas a magnetic ray emitted from the N pole of the other magnet (7f) returns to the S pole of the same magnet (7f), and thus, closed loops are respectively formed. In such a case, the rotor (11) becomes suctioned based not only on the electrostatic suction force between adjacent members of the drive electrodes P1 ~ P8 but also on the magnetic force between the magnets (7e) and (7f), based on

which the contiguation force between the rotor (11) and stator (1) increases, resulting in an increase in the frictional force.

As far as this application example is concerned, furthermore, the respective inner diameters of both magnets (7e) and (7f) are designated to be slightly smaller than the respective inner diameters of the drive electrodes P1 ~ P8, and the inner circumferential planes of the magnets (7e) and (7f) collectively serve as the rotor tumble plane (5). For this reason, the rotor (11) becomes tumbled on the inner circumferential planes of the magnets (7e) and (7f) without being contacted with /4 the drive electrodes P1 ~ P8. Unlike the drive electrodes P1 ~ P8, neither the magnet (7e) nor (7f) possesses the air gap (4), and therefore, the rotor (11) becomes smoothly rotated without dipping into the air gap (4), and the rotation noise is also minimized.

Figures 5 (a), (b), and (c) show still another application example of the present invention. As far as this harmonic drive-type electrostatic motor C is concerned, the respective structures of the magnets (7g) and (7h), which are configured on both sides of the drive electrodes P1 ~ P8 on the inner circumferential plane of the stator casing (2), differ from their counterparts of the application example shown in Figures 4 (a) and (b). As far as this application example is concerned, the respective magnets (7g) and (7h), which are each characterized by a cylindrical shape, are divided into multiple parts, as Figure 5 (a) indicates, and each magnet piece (10) is polarized between the inner circumferential plane side and the outer circumferential plane side, whereas the

polarization directions of adjacent members of the respective magnet pieces (10) are mutually opposite.

Incidentally, as far as the aforementioned application example is concerned, drive electrodes are configured on the inner circumferential plane of the stator casing while the rotor is being inserted into the hollow interior space of the stator (inner rotor format), although the present invention is not limited to this type of harmonic drive-type electrostatic motor, and it is also applicable to a constitution wherein drive electrodes are configured on the outer circumferential plane of a stator casing and wherein a cylindrical rotor is externally interfaced with the outer circumference of the stator (outer rotor format).

(Effects of the invention)

As far as the present invention is concerned, a suction force ascribed to a magnet is exerted between a rotor and a stator, based on which the frictional force between the rotor and stator becomes elevated, and even in a case where a high load is impressed on the rotor, the slip of the rotor becomes unlikely, and the output torque increases.

Even if no voltage is impressed between the rotor electrode and drive electrodes, furthermore, a holding torque can be generated by the magnet. The hover of the rotor from the rotor tumble plane can therefore be avoided even when the rotor becomes desynchronized, and the slip of the rotor can be prevented.

4. Brief explanation of the figures

Figures 1 (a) and (b) are respectively diagrams which show a frontal view and a cross-sectional view of an application example of the present invention, whereas Figure 2 is an approximate constitutional diagram which shows a method for driving the motor of the same, whereas Figure 3 is a time chart which shows the variations of the voltages impressed on the respective drive electrodes of the same, whereas Figures 4 (a) and (b) are respectively diagrams which show a frontal view and a cross-sectional view of another application example of the present invention, whereas Figures 5 (a) and (b) are respectively diagrams which show a frontal view and a cross-sectional view of still another application example of the present invention, whereas Figure 5 (c) is a diagram which shows a cross-sectional view of the Z-Z segment of Figure 5 (b), whereas Figures 6 (a) and (b) are respectively diagrams which show a frontal view and a cross-sectional view of harmonic drive-type electrostatic motor explained in the section of the "Background Technology."

(1): Stator; (2): Stator casing; P1 ~ P8: Drive electrodes; (7a) ~ (7h): Magnets; (11): Rotor; (12): Rotor electrode; (13): Insulating film.

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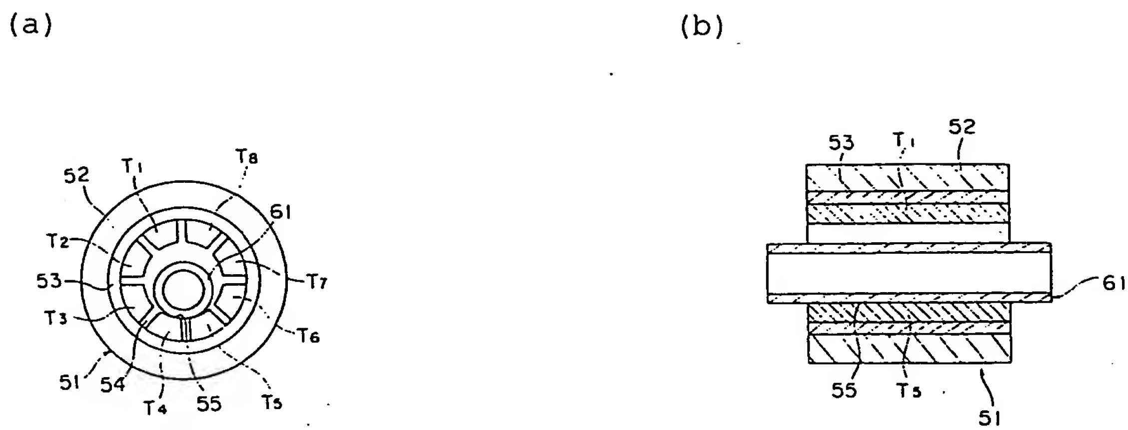
Figures 6



Figures 1

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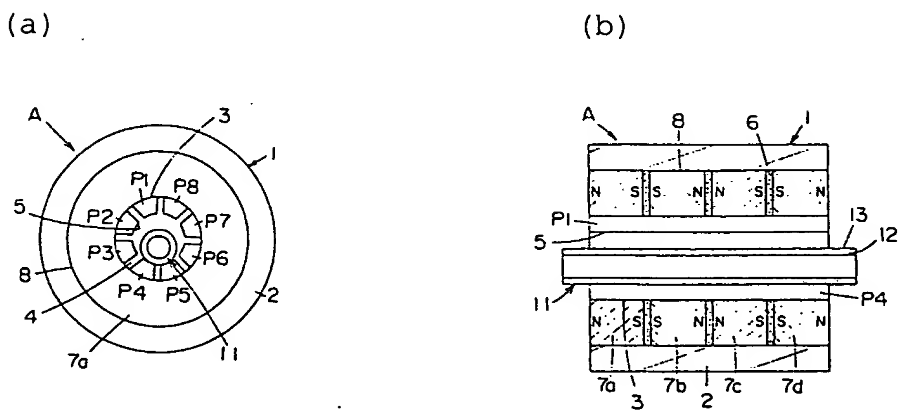
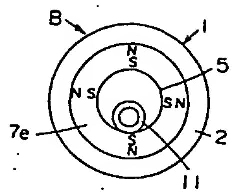


Keys:

[(1): Stator; (2): Stator casing; P1 ~ P8: Drive electrodes; (5): Rotor tumble plane; (7a) ~ (7h): Magnets; (11): Rotor; (12): Rotor electrode; (13): Insulating film]

Figures 4

(a)



(b)

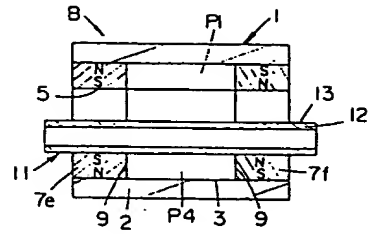
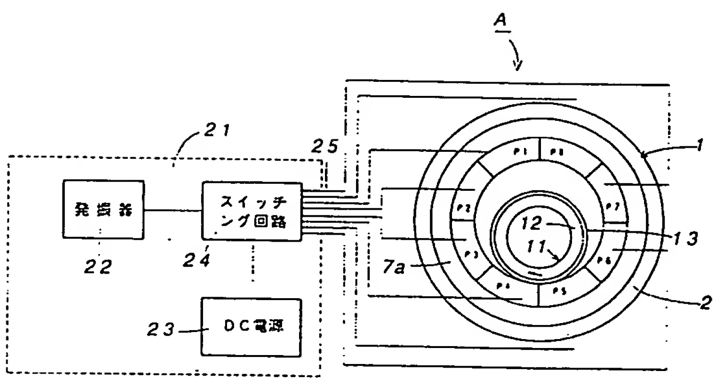
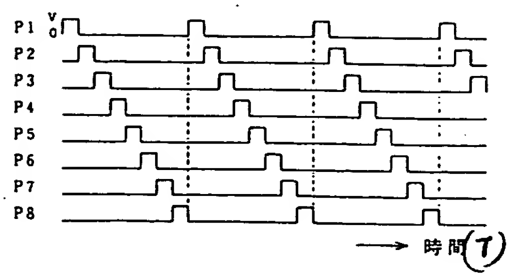


Figure 2



[(22): Oscillator; (23): DC power source; (24): Switching circuit]

Figure 3



[(T): Time]

Figures 5

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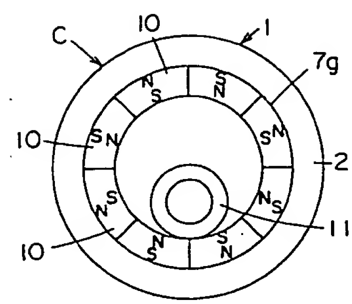
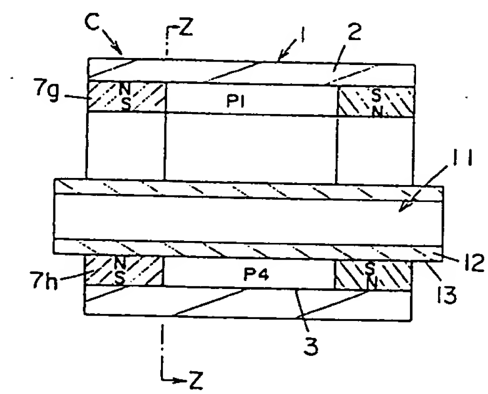
(a)



(b)



(c)